

REMARKS

Summary of Amendments

Claims 1-3 have been extensively amended to more particularly point out and distinctly claim the recited subject matter of the present invention.

By the present amendment, the limitations of claim 4 have been incorporated into claim 3; thus, claim 4 has been canceled.

Claim 5 remains as it was slightly revised in the August 6, 2007 reply to the previous Office action on the merits, while claims 6 through 10 have been canceled.

Accordingly, **claims 1-3 and 5** are pending reconsideration by the Examiner.

Claim Rejections – 35 U.S.C. § 102

Claims 1 and 2 were rejected under 35 U.S.C. § 102(b) as being anticipated by U.S. Pat. App. Pub. No. 2002/0121863 to Morishita.

Morishita is a published U.S. patent application that seems to have nothing more to do with the present application than the fact that it discloses a GaN substrate. Specifically, as far as processing GaN substrates, and the processed GaN substrates themselves, are concerned, *Morishita* only teaches, in paragraph [0048], back-side polishing or etching GaN substrates to bring down the substrate thickness—a standard procedure carried out to ready substrates for cleaving once devices have been fabricated on the substrates. *Morishita* is completely silent as to levels of residual contaminants on GaN substrates, or, for that matter, as to any issues regarding *how* clean the GaN substrates are, or regarding *how to* clean the GaN substrates.

In making the § 102 rejection of claims 1 and 2, the Office refers Applicant to *Morishita*, and simply states that therein the "GaN substrate has no manmade elemental metals such as europium." On first reading, Applicant's undersigned representative found the intent of this statement hard to grasp. *Morishita* only mentions manmade metals including europium in three places, each similarly listing metals that may be used to form the *p*-type and *n*-type electrodes on the *Morishita* laser diodes that are the principal focus of this cited reference. As noted in the previous paragraph, *Morishita* gives no specifics whatsoever on substrate surface contamination.

Attempting to grasp the Office's position in rejecting claims 1 and 2 over *Morishita*, then, calls for reexamining just what the claims set forth. These two independent claims recited a GaN substrate, limited solely by the characterization that "metal contamination on the substrate surface is 10×10^{11} atoms/cm² or less." It is believed that, presented with such claims, the Office has in effect pointed out that inasmuch as *Morishita* teaches fabricating a laser diode having *p*- and *n*-type electrodes made of a given alloy, and lists other metals that may be used to fashion the electrodes instead of the given alloy, then those other metals are *totally absent* from the devices.

In paragraph [0040], *Morishita* teaches providing an *n*-type electrode 404 directly onto the rear surface of GaN substrate 401. In paragraph [0060], *Morishita* states that the *n*-type electrode 404 is a Ti-Al alloy, and lists other metals, including europium, which may be used instead. Hence, it may be said that inasmuch as *Morishita* teaches a GaN substrate provided on its backside with an *n*-type electrode made of Ti-Al but that could be made of certain other metals, then the *Morishita* GaN substrate is completely free of any "contamination" by such other metals—simply because the only possible metals that could be "contaminating" the backside of the GaN substrate are Ti or Al.

In short, it appears that the Office's position is that *Morishita* anticipates claims 1 and 2 by teaching a GaN substrate on the backside of which *non-Ti* and *non-Al* metal "contamination" is 10×10^{11} atoms/cm² or less.

Furthermore, the fact that the Office states that in *Morishita*, the GaN substrate "has no manmade elemental metals" suggests an understanding that the claim 1 and 2 recitation in question is meant refer to the metal contaminants that are a by-product of the reactive-ion etching process carried out according to the present invention. That is, the metal contaminants that claims 1 and 2 refer to are the "metal oxides, silicides, or similar metal compounds" resulting from the dry-etching process carried out on the GaN substrate (paragraph [0020] of the present specification).

Claims 1 and 2 have been amended to: clarify that they are not intended merely to recite that any one metal that exists is not present on either side of the GaN substrate, or is only present in the amount 10×10^{11} atoms/cm² or less; to recite which side of the substrate is free of metal contaminants; and, in effect, to recite how much of that side is contaminant-free to the claimed level, and of which metals is that side free of contamination.

It is to be noted that the specification gives a sixth object of the invention, "to make available a method of evaluating the type and quantity of metal that remains behind on the surface of a GaN substrate." The method is described in the present specification in the passage that begins under the heading "Photoluminescence Assay" above paragraph [0133].

The present claim amendments capture the gist of this photoluminescence assaying technique into claims 1 and 2 by requiring that a light-emitting-device-forming film has already been epitaxially grown onto the claimed GaN substrate, wherein the photoluminescence of the GaN substrate having the light-emitting-device-forming film is uniquely correlated to, as an indication of the reduced level of, metal contamination on the substrate.

Namely, claims 1 and 2 now recite,

A gallium-nitride semiconductor substrate onto which a light-emitting-device-forming film has been epitaxially grown, characterized by photoluminescent emission from the device-forming film under a predetermined monochromatic beam correlating to a metal-atom density level of [claim 1: 10×10^{11} ; claim 2: 5×10^{11}] atoms/cm² or less on the GaN substrate surface.

It is respectfully submitted that for the foregoing reasons, claims 1 and 2 are not anticipated by *Morishita* and thus should be held allowable.

Claim Rejections – 35 U.S.C. § 103

Claim 3: *Toda et al.* '120

Claim 3 was rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. Pat. No. 6,791,120 to *Toda et al.*

As the Office acknowledges, *Toda et al.* makes no teaching regarding oxidation-reduction potential of a wet etchant. Column 8, line 26 through column 9, line 51 of *Toda et al.* do teach:

- (i) mechanically polishing a GaN substrate with an abrasive "arranged on" a buff 13 on a glass plate 11, which can alternatively be made of metal;
- (ii) using a chlorine plasma to reactive-ion etch (RIE) the substrate; and
- (iii) wet-etching the substrate in 10% HCl.

Yet *Toda et al.* mentions nothing as to oxidation-reduction potential of the etchant.

Furthermore, column 9, lines 49-52 of *Toda et al.* state, "Thus, chlorine-based residues adhering to the back surface of the n-type GaN substrate 1 in the RIE step are removed." (Emphasis added.) *Toda et al.* may be summarized as disclosing a method of processing the backside of a GaN substrate onto which a laser device has been fabricated.

The method according to present invention is meant to be carried out on a particular form of GaN substrates. Paragraphs [0023] and [0024] of the present specification state,

[T]he GaN manufactured by the present applicants does not possess a uniform Ga face and a uniform N face. The present applicants have adopted a method (which they have provisionally termed the "stripe growth method") of growing crystal GaN by means of a technique in which in order to reduce the dislocation density, defect-gathering areas in stripe form are deliberately created within the crystal, causing defects to collect there.

(. . .)

The GaN . . . is such that the non-stripe face is the Ga face and the stripe face is the N face, and is complicated by being formed with the Ga face alternating with the N face.

Accordingly, this unique "stripe-growth" method is practiced to reduce dislocations in growing bulk GaN for substrates, but ridding the substrate surface, with its intermingled Ga faces and N faces, of contaminants without leaving the surface pitted becomes problematic. It is this problem that a GaN substrate-processing method according to the present invention uniquely addresses.

Claim 3 has been extensively amended, not only to incorporate the limitations of claim 4, but also to: recite a new step, that of "providing a gallium-nitride semiconductor substrate having a complex front side in which the Ga and N faces are exposed in alternation"; to recite that the claimed polishing step is limited to "polishing the substrate front side" so as to "transform the substrate episurface into a process-transformed layer"; and to add a new limitation to the etchant employed in the claimed wet-etching step—that is, that the etchant is "in a room-temperature aqueous solution of pH = 2 to 3."

In respect of this last-mentioned limitation, the experimental examples described in the present specification set forth that the etchant employed in the wet-etching procedures is in an "aqueous solution of pH = 2 to 3." The acidic wash (wet etchant) employed in Experimental Examples 3-5 achieves the superior results sought under the present invention, in contrast to Experimental Examples 1 and 2, which involve only conventional organic-solvent washing.

Thus, a GaN substrate-processing method according to the present invention achieves the fifth-stated object:

to make available a wet etching method rendered so as not to produce roughness due to the crystallographic orientation even with GaN wafers possessing complex surfaces in which the Ga face and N face alternate with each other.

Claim 3 now reads:

A method of processing a gallium-nitride semiconductor substrate, the method comprising:

providing a gallium-nitride semiconductor substrate having a complex front side in which the Ga and N faces are exposed in alternation;

polishing the substrate front side with an abrasive embedded into a metallic platen, thereby transforming the substrate episurface into a process-transformed layer;

reactive-ion etching the substrate front side using a halogen plasma to remove the process-transformed layer; and

wet etching the reactive-ion etched substrate, by means of an etchant that is one of HF + H₂O₂, HCl + H₂O₂, H₂SO₄ + H₂O₂, HNO₃ + H₂O₂, HF + O₃, HCl + O₃, H₂SO₄ + O₃, HNO₃, or HNO₃ + O₃, and that has an oxidation-reduction potential of more than 1.2 V, in a room-temperature aqueous solution of pH = 2 to 3, thereby to remove contaminant metal produced by said reactive-ion etching.

It is respectfully submitted that for the foregoing reasons, claim 3 is patentable over *Toda et al.* regardless of any combination of the teachings of this reference with the knowledge of one skilled in the art

Claim 4: Suguro et al. '214

Claim 4 was rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. Pat. App. Pub. No. 2004/0266214 to Suguro et al.

By the present amendment, claim 4 has been canceled.

Claim 5: Toda et al. '120; further in view of Flynn et al. '964

Claim 5 was rejected under 35 U.S.C. § 103(a) as being unpatentable over *Toda et al.* as applied in making the above-addressed rejection of claim 3, and further in view of U.S. Pat. App. Pub. No. 2003/0213964 to Flynn et al.

For the reasons set forth above in addressing the separate rejection of claim 3 over *Toda et al.* in combination with the knowledge of one skilled in the art, claim 3 is believed to be allowable. Claim 3 being allowable, it follows that claim 5, which is a proper dependent claim containing all of the limitations of independent claim 3, should also be allowable. Thus, it is respectfully submitted that the rejection of claim 5 need not be addressed any further.

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Claim 6: *Suguro et al.* '214; further in view of *Flynn et al.* '964

Claims 7 and 8: *Toda et al.* '120

Claims 9 and 10: *Suguro et al.* '214

Claims 6 through 10 were rejected under 35 U.S.C. § 103(a) as being unpatentable over individually specified ones of the references cited by the Office in rejecting claims 3 through 5.

By the present amendment, 6 through 10 have been canceled.

Conclusion

Accordingly, it is believed that the rejections have been overcome and thus that the issues impeding allowance of this application have been resolved. Nonetheless, if, despite Applicant's thus having made their best attempt to advance the prosecution of this case, the Office finds that there are issues still standing in the way of allowance, the Examiner is courteously urged to contact Applicant's undersigned representative at an early date, for the sake of resolving any such issues so as to avert further rejection of the pending claims.

Respectfully submitted,

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